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Foramen Venosum in macerated skulls from the North-East of Brazil: morphometric study

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SUMMARY

The foramen venosum (FV) is a small, inconstant orifice in the middle cranial fossa, located anterior and medial to the foramen ovale (FO). The object of the present study was to analyse the frequency of the FV, its side of appearance, diameter and distance from the FO, in macerated skulls of adult Brazilians from the north-eastern region of Brazil. 194 macerated skulls were analysed. The diameter of the FV and its distance from the FO (FV-FO) were measured with a digital calliper. The FV was present in 18.5% of the skulls. Unilateral presence (12.4%) was more frequent than bilateral (6.1%). When unilateral, the FV was more frequent on the left side (9.3%) than the right (3.1%). We observed asymmetry in the size of the FV, which was larger on the left side (p=0.043). No statistically significant difference was observed between sides for FV-FO, however this distance was significantly greater in women than in men (p=0.006). The FV is an important anatomical variation, and may occur bilaterally or unilaterally. It is asymmetrical, with larger diameter found on the left side. The findings of this study provide important information for surgeons and morphologists on the anatomy of the middle cranial fossa.

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INTRODUCTION

The foramen venosum (FV), also known as the foramen of Vesalius, is located in the greater wing of the sphenoid bone, anterior and medial to the foramen ovale (FO) (Testut and Latarjet, 1979). According to Wood-Jones (1931), the FV does not exist in any other primate, but is an exclusive characteristic of the human being. The FV transmits an emissary vein through the cavernous sinus, communicating with the pterygoid plexus (Lanzieri et al., 1988). In clinical practice, the failure of some percutaneous procedures for treating trigeminal neuralgia is often attributed to the presence of the FV (Gusmão et al., 2003). Furthermore, the communication which the FV provides with the pterygoid plexus through an emissary vein is responsible for propagating extracranial infections, for example infections of dental origin, to the cavernous sinus (Dogan et al., 2014; Alves and Deana, 2016). One complication which may occur when the FV is present is perforation of the emissary vein during percutaneous rhizotomy of the trigeminal nerve, when the needle is accidentally introduced into the FV instead of the FO; this may cause serious complications,

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Fig 1. Image of the middle cranial fossa, showing the foramen venosum (arrow), foramen ovale (asterisk) and spinosum foramen (double arrow).

such as temporal haematomas (Martínez et al., 2007).

Knowledge of the morphology of the cranial base is essential in order to carry out procedures safely in this region. It is also important to be familiar with the anatomy of the cranial base when analysing tomographic images of the region in order to avoid confusion in comparing normal variations with abnormal findings (Keskil et al., 2003).

Detailed study of the morphological characteristics of every population is important, since several factors influence growth and development, e.g. genetic, endocrine and environmental factors, determining intrapopulational and interpopulational variation (Faulhaber, 1989). Brazilians form one of the most heterogeneous populations in the world, the result of 5 centuries of interethnic crosses between peoples of 3 continents: Europeans, African slaves and autochthonous Amerindians (Parra et al., 2003). Kehdy et al. (2015) carried out a study on the genome of the population of Latin America, finding that the miscegenation in the north-east of Brazil is much greater than in the south-east of the country. In the north-east the percentage of African descent is 50%, while 70% of the population in the south-east is of European origin. These interpopulational genetic differences determine morphological differences in Brazilian individuals, indicating the need for a detailed study on the morphological/anatomical characteristics of the population. The object of the present study was to analyse the frequency of the FV, its side of appearance, diameter and distance from the FO, in macerated skulls of adult Brazilians from the north-eastern region of Brazil.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Universidade Federal da Paraíba, opinion number 32265714. 0.0000.51880.

We examined 388 half-heads of 194 macerated skulls of adult Brazilians from north- eastern Brazil, 118 males and 76 females, belonging to the Department of Morphology of Universidade Federal da Paraíba, Paraíba, Brazil. The first aspect analysed was the frequency and side of appearance of FV. We also analysed the greatest diameter of the FV and the distance to the FO (FV -FO) using a Mitutoyo® digital calliper, duly calibrated and accurate to 0.02 mm (SI). The correlation between the diameter and FV-FO was analysed for both right and left sides.

The Kolmogorov-Smirnov test was used to evaluate the normality of the sample. ANOVA, Student's t-test and Spearman's correlation were used for statistical analysis. The data were analysed with SPSS 15 for Windows. Results were considered statistically significant at $p<0.05$.

Table 1. Distance from the foramen venosum to the foramen ovale (FV-FO), frequency and diameter of FV, according to the literature.

Authors	Year	*n*	Frequency (%)	Diameter (mm)		Distance FV-FO (mm)	
				Average	SD	Average	SD
Alves and Deana	2017	178¥	32.02	-	-	1.61-2.29R	-
Chaisuksunt et al.	2012	754¥	10.9	1.5	±0.7	-	-
Dogan et al.	2014	62¥	32.3	1.3	±0.5	3.61	±1.92
Ginsberg et al.	1994	123¥	80.0	-	-	-	-
Gupta et al.	2005	35¥	42.9	-	-	-	-
Kim and Kim	1995	305¥	47.5	-	-	-	-
Kodama et al.	1997	400¥	21.75	-	-	-	-
Lanzieri et al.	1988	54¥	72.2	-	-	-	-
Lazarus et al.	2015	100†	-	1.93	±0.46	2.63	±1.24
Ozer and Govsa	2015	172¥	34.8	0.9	±0.3	2.38	±1.02
Reymond et al.	2005	100¥	17.0	-	-	-	-
Rossi et al	2010	80¥	40	1.45*-1.59**		1.85*-2.46**	
Shaik et al.	2012	250¥	36.0	-	-	-	-
Shinohara et al.	2010	400¥	33.75	0.65	-	2.55*-2.59**	-
Srimani et al.	2014	80¥	5.0	-	-	-	-
Present Study		194¥	18.55	2.89	±0.99	3.67	±0.76

†Sides, ¥Skulls, SD Standard Deviation, (-) Not informed, *right side, **left side, Rrange

RESULTS

FV (Fig. 1) was found in 36/194 skulls (18.5%), with an oval or elliptical shape. Of these, 17 were male (8.7%) and 19 female (9.8%). Bilateral presence of the FV was observed in 6.1% of the skulls, right unilateral presence in 3.1%, and left unilateral presence in 9.3%.

The mean diameter of the FV was greater on the right side than the left (3.23 ± 4.6 mm and 2.59 ± 4.2 mm respectively), with a statistically significant difference between sides (p=0.043). The mean diameter of the FV was greater in women (3.08 ± 0.99 mm) than in men (2.65 ± 1.03 mm), however no statistically significant difference was observed between sexes (p=0.156).

The mean value of FV-FO was larger on the left side (2.55 ± 1.37 mm) than the right (2.90 ± 2.28), (p=0.506). The mean FV-FO was greater in women (3.06±1.24 mm) than in men (2.05 ± 1.19 mm), with a statistically significant difference observed between sexes (p=0.006).

We observed good positive correlation between the diameter of the FV and FV-FO on the right side ρ=0.601 (p=0.008), and moderate positive correlation on the left side ρ=0.501 (p=0.004).

DISCUSSION

The FV is an inconstant orifice in the greater wing of the sphenoid bone (Testut and Latarjet, 1979). An emissary vein passes through the foramen which communicates the cavernous sinus with the pterygoid plexus (Padget, 1956; Testut and Latarjet, 1979). The embryonic development of the region of these foramina is complex, starting with the alisphenoid cartilage and the obturator membrane (Fawcett, 1910). When the cranial base is in formation, the foramina are orifices resulting from the impression of their elements (nerves and vessels) on the junction of different embryonic components (Moore et al., 2011).

According to Vesalius (1543), the FV is rarely found on one side of the cranium, and even more rarely on both sides. In the literature it is observed that the frequency of the FV is quite variable, with percentages reported from 5% (Srimani et al., 2014) to 80% (Ginsberg et al., 1994). In our

study, the FV was present in 18.55% of skulls, a similar percentage to that reported by Kodama et al. (1997) (21.75%) and Reymond et al. (2005) (17%) (Table 1). This figure is lower than those reported by Alves and Deana (2017) at 32.02%, and Shinohara et al. (2010) at 33.75% in studies also carried out in Brazilians. It is possible that the lower percentages found in our study were due to the fact that the data reported previously were of individuals from places in the south-east of Brazil, where the type of miscegenation is different from that found in the north-east of the country (Kehdy et al., 2015), resulting in an interpopulational variation. In a recent study of 400 skulls of adult Japanese, Kodama et al. (1997) reported that the FV was present in 21.75%, with bilateral FV (75.36%) expressively more frequent than unilateral (24.64%). Chaisuksunt et al. (2012) and Reymond et al. (2005) reported that the bilateral FV was present in only 4.2% and 5% of skulls respectively. More expressive percentages of bilateral FV have been reported by other authors: 13.75% (Rossi et al. 2010), 14.7% (Boyd, 1930), 15.5% (Shinohara et al., 2010), while Berge and Bergman (2001) reported an even higher percentage of bilateral presence of 35%. In the present study only 6.18% of skulls presented bilateral FV.

In the present study, unilateral FV was found more frequently than bilateral, corroborating the findings of Chaisuksunt et al. (2012), Ginsberg et al. (1994), Reymond et al. (2005) and Rossi et al. (2010). In Alves and Deana (2017) and Kodama et al. (1997) the incidence of FV was principally bilateral. In the present study unilateral FV on the left side was significantly more frequent than on the right, similar to the findings of Chaisuksunt et al. (2012) Reymond et al. (2005); whereas in Boyd (1930), Dogan et al. (2014), Ginsberg et al. (1994) and Rossi et al. (2010), the FV was more frequent on the right side, and in Alves and Deana (2017) and Kodama et al. (1997) there was no significant difference between sides.

According to Boyd (1930), 65% of FV present a diameter of 0.5-1 mm, in 5% the diameter is 1-2 mm and it occasionally measures close to 2.5 mm. According to Lazarus et al. (2015), a diameter of up to 0.5 mm favours safer and more reliable percutaneous procedures than larger apertures. In the present study, the mean diameter of the FV was 2.89 mm, larger than reported by other authors of between 0.65 mm and 1.93 mm (Chaisuksunt et al., 2012; Dogan et al. 2014; Lazarus et al. 2015; Ozer and Govsa, 2015, Rossi et al., 2010; Shinohara et al., 2010) (Table 1). We observed in our study that the diameter of the FV was significantly larger on the left side than the right, corroborating the findings of Chaisuksunt et al. (2012) and Lanzieri et al. (1988) who noted that the asymmetry in the size of the FV results from a pathological process and is not a normal variation. It may be associated with various conditions, including nasopharyngeal melanoma, angiofibroma, fistula of the emissary vein with the internal carotid artery, and neurofibromatosis. Chaisuksunt et al. (2012) reported that there were no differences between sexes in the size of the FV, similar to the findings in our study.

The FV-FO measurement was similar on both sides in our study, corroborating the findings of Ozer and Govsa (2015) and Shinohara et al. (2010). The mean values found in the present study were similar to those reported by Dogan et al. (2014), but higher than those in Alves and Deana (2017), Lazarus et al. (2015), Ozer and Govsa (2015), Rossi et al. (2010), and Shinohara et al. (2010) (Table 1). Alves and Deana (2017) reported that white women present smaller values for FV-FO, mean 1.61 mm, while white and black men and black women present similar mean values (2.20 mm, 2.08 mm and 2.29 mm respectively). It should be noted that important sexual differences exist for FV-FO, and the surgeon must not fail to consider these differences when planning surgery (Alves and Deana, 2017).

Our study showed a relation between the diameter of the FV and FV-FO, on both sides, which conflicts with the findings of Shinohara et al. (2010) and Ozer and Govsa (2015), who reported that they did not find any correlation between these variables.

Clinical Implications

As this foramen is inconstant, it may be a complicating factor in a surgical procedure in the region when the professional does not possess well-founded anatomical knowledge (Alves and Deana, 2017). Percutaneous procedures for treating trigeminal neuralgia are all based on access to the FO (Leocádio et al., 2014). In these procedures, puncture of the cavernous sinus and haematoma of the temporal lobe have often been attributed to the presence of the FV (Gusmão et al., 2003; Sweet, 1968; Sindou et al., 1987).

The cavernous sinus and the pterygoid plexus are connected by an emissary vein in the FO, although the communication may pass through the FV, the foramen lacerum or the foramen rotundum (Butler, 1957; Browder, 1976; Kaplan, 1976; Henderson, 1966). This emissary vein is located below the trigeminal ganglion and the proximal segments of the maxillary and mandibular nerves, which are those most subject to trigeminal neuralgia (Leocádio et al., 2014). Apart from this vein and the mandibular nerve, the FO may also contain an accessory meningeal artery and the lesser petrosal nerve (Testut and Latarjet, 1979).

Anatomical knowledge of the FV and its relation to the FO are important for percutaneous techniques involving the trigeminal nerve, due to the complexity of the topography around the access

to this nerve; the inconstancy and morphometric variability of the FV and its proximity to the FO; and the relation with the mandibular nerve, the accessory meningeal artery, the lesser petrosal nerve and the emissary vein.

Study limitations

One limitation of our study is the absence of information on the age and ethnic group of the skulls used, making comparison impossible with other investigations published previously which include this information.

Conclusions

The FV is an important anatomical variation, which may occur bilaterally or unilaterally. When it is unilateral, it tends to present more frequently on the left side than the right. It is quite asymmetrical, with larger diameter found on the left side. The findings of this study provide important information for surgeons and morphologists on the anatomy of the middle cranial fossa.

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